Unit-5

Image Enhancement in the Spatial Domain

"It makes all the difference whether one sees darkness through the light, or light through the shadows"
David Lindsay

Section 3.1 to 3.4 in Text Book*

* Digital Image Processing by Gonzales

Image Enhancement in the Spatial Domain

- ***Background***
- ***Some Basic Gray Level Transformations***
  - Image Negatives
  - Log Transformations
  - Power-Law Transformations
  - Piecewise-Linear Transformation Functions
- **Histogram Processing**
- **Enhancement Using Arithmetic/Logic Operations**

Image Enhancement in the Spatial Domain

- ***Background***
- ***Some Basic Gray Level Transformations***
- **Histogram Processing**
  - ➔ Histogram Equalization
  - ➔ Histogram Matching
  - ➔ Local Enhancement
  - ➔ Use of Histogram Statistics for Image Enhancement
- **Enhancement Using Arithmetic/Logic Operations**
  - ➔ Image Subtraction
  - ➔ Image Averaging

Why perform image enhancement?

- Process images to obtain results more suitable than the original image for 'specific' apps
- Specificity of applications implies no single standard method of processing
- Ex: Enhancing X-ray images and Hubble space telescope images would not employ the same methods!

Methods of Image enhancement

(1) **Spatial Domain** -> Image plane itself; Direct manipulation of pixels

(2) **Frequency Domain** -> Based on Fourier transform of images

General Theory of Image Enhancement

- There is none!
- Visual evaluation is higly subjective, and there can be no general methods that can be employed!

  Ex: Between us, the perception certainly varies!

- For machine perception, we could converge to somewhat standard methods

  Ex: Character recognition by machines

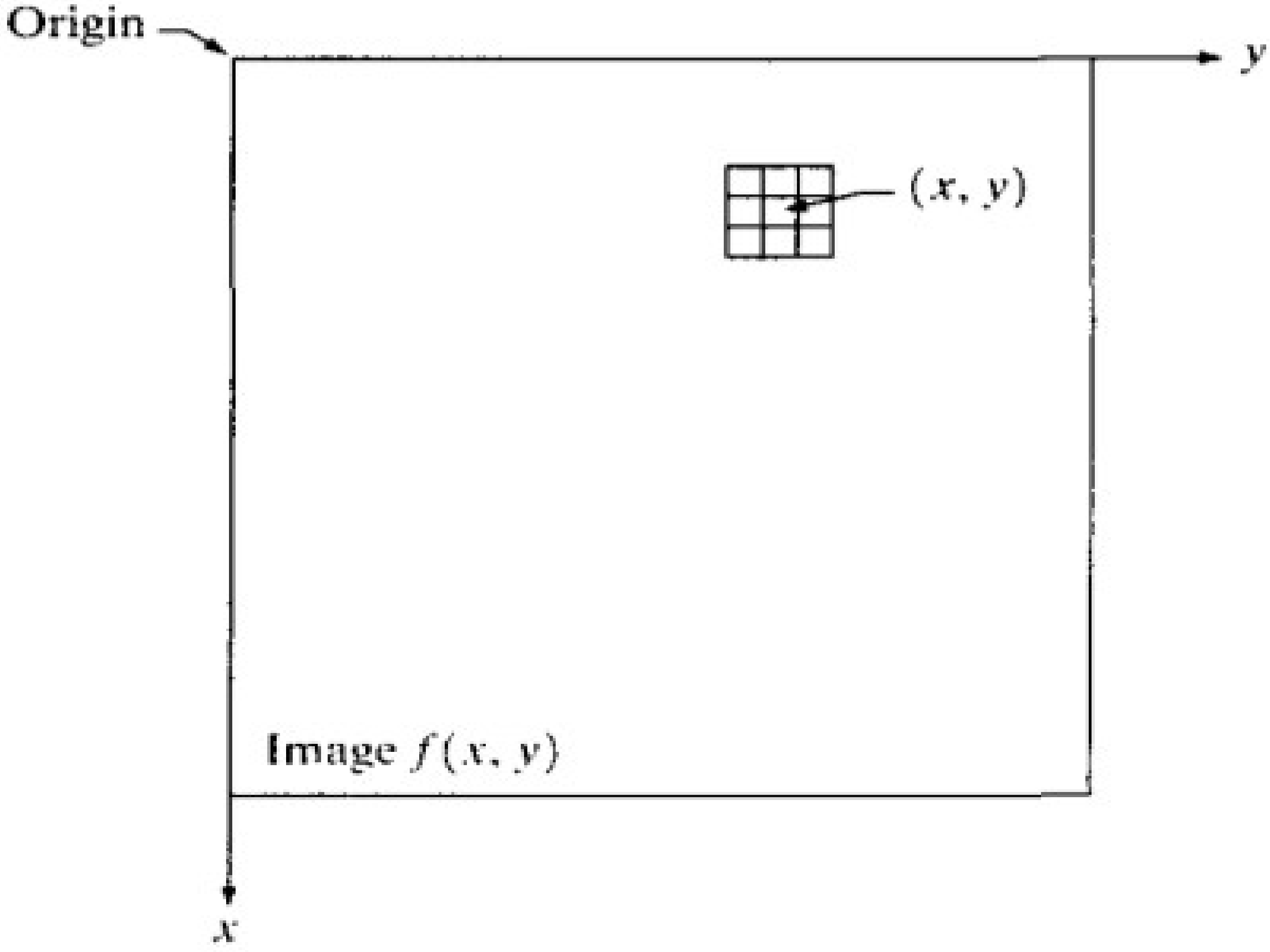
Spatial Domain?

- It refers to the aggregate of pixels composing an image
- Spatial Domain methods are procedures operating directly on these pixels

$$g(x,y)=T[\ f(x,y)\ ]$$

where, f(x,y) & g(x,y) are the input and processed images respectively;
T is the Transform Operator on ***f*,** over a defined area (x,y)

Defining a neighborhood



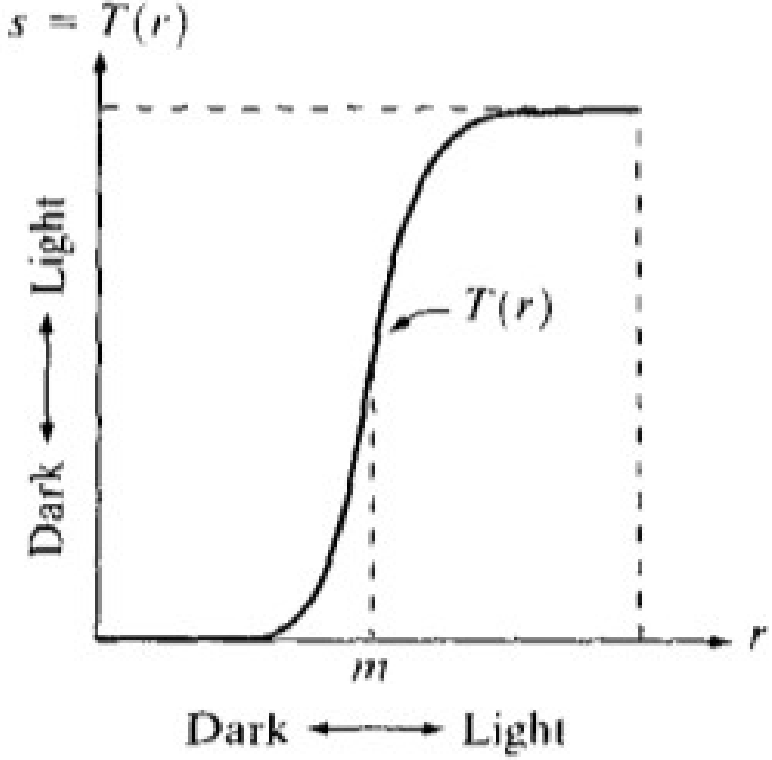
Simplest form of T

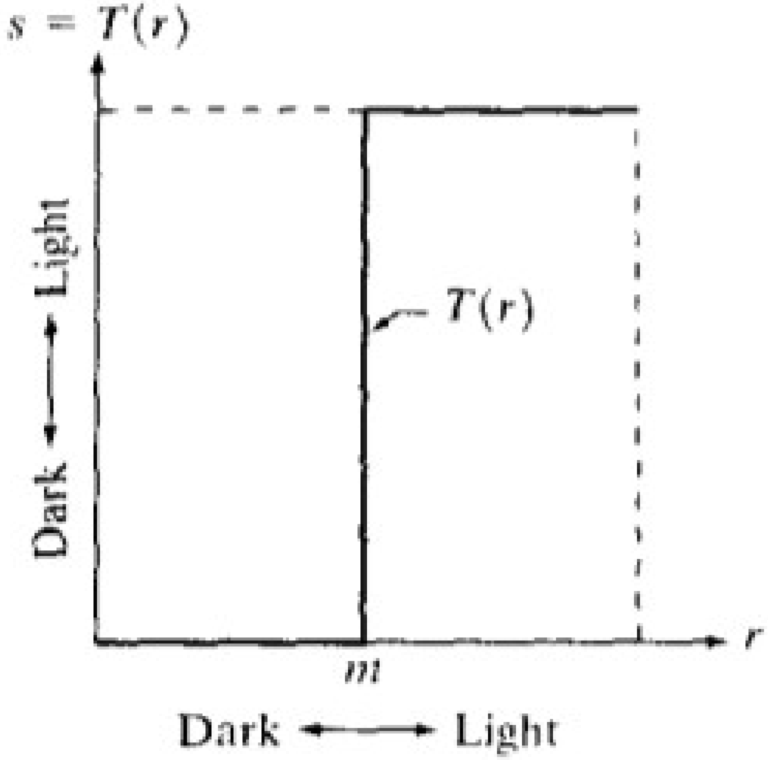
- When the neighborhood is of size 1x1
- 'g' depends only on the value of *'f'* at (x,y) and T becomes a *Gray Level Transformation function*

$$s=T(r)$$

r & s denote the gray levels of f(x,y) and g(x,y)

Contrast stretching as an example





*** Thresholding function**
*** Point Processing**

Basic Gray Level Transformations

- **Linear :** Negative and Identity transforms
- **Logarithmic :** Log and inverse log transforms
- **Power Law:** n^{th} power and n^{th} root transforms

Basic Gray Level Transformations

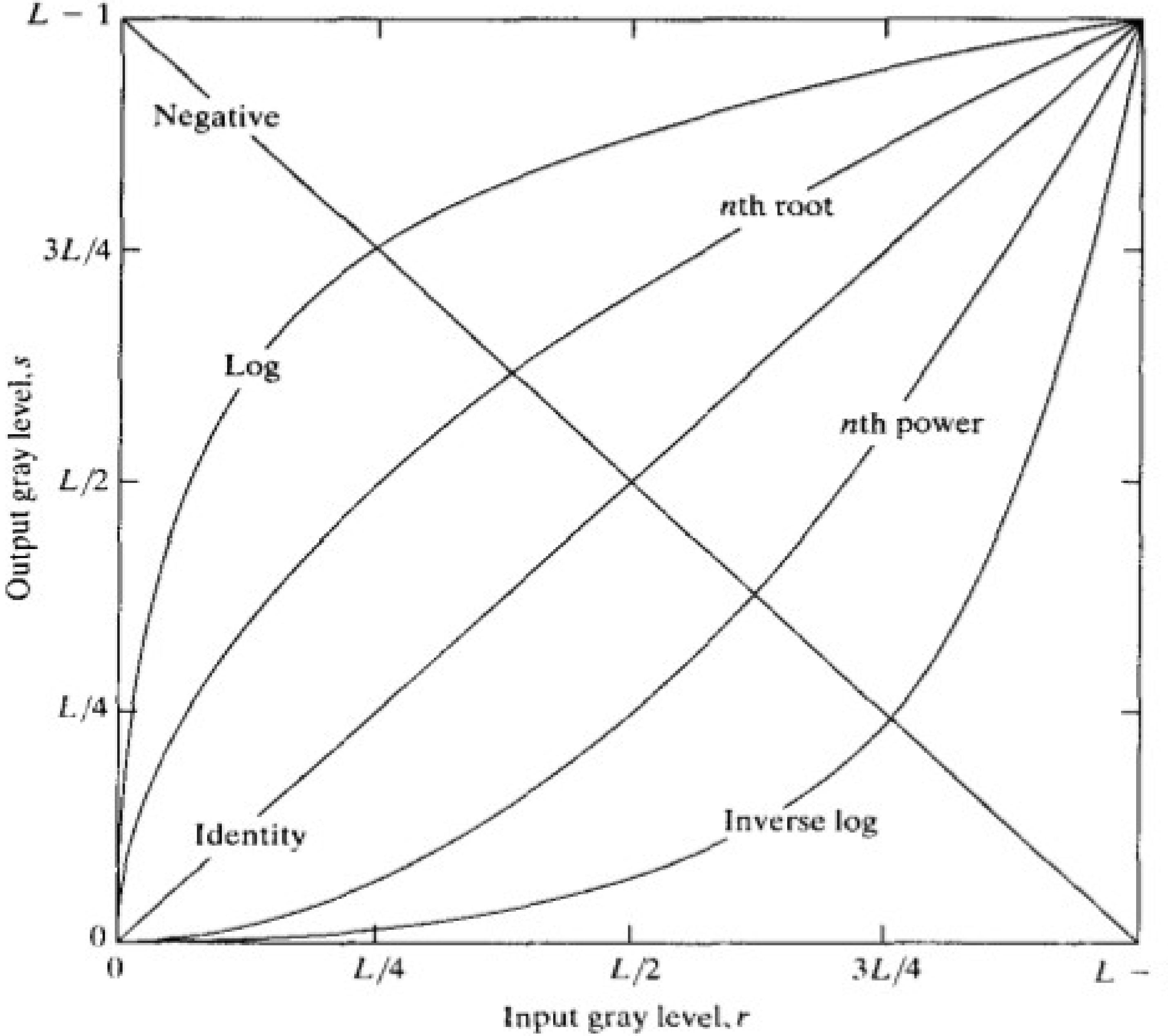


Image Negatives

$$s = L - 1 - r$$

For enhancing white or gray detail embedded in dark regions of an image

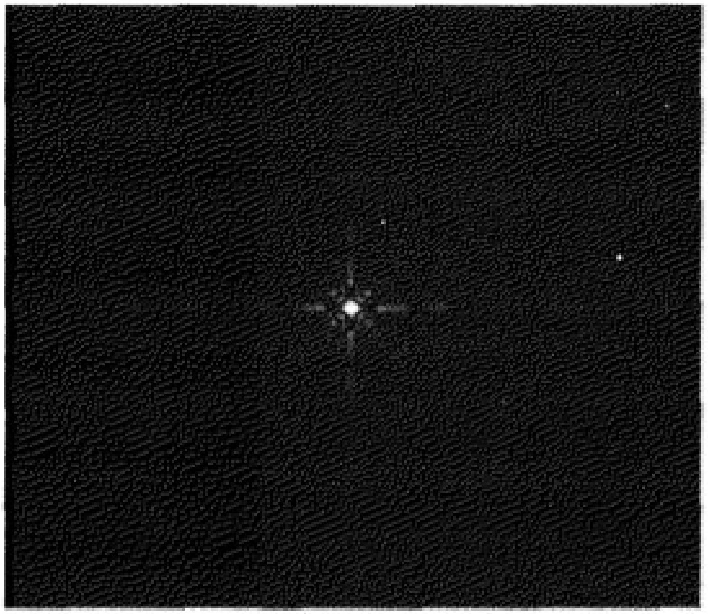
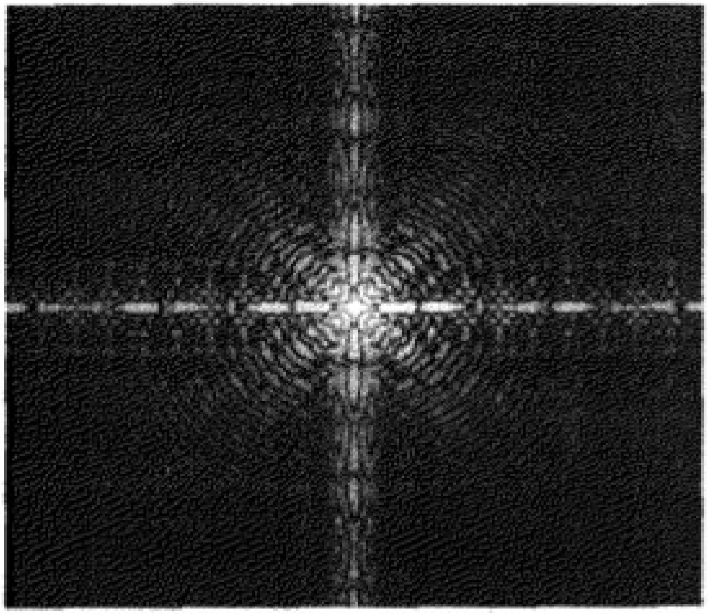
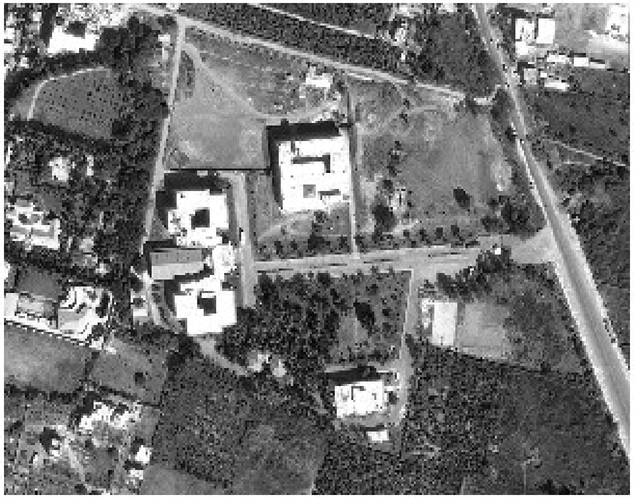
Log Transformations

$$s = c*\log(1+r)$$

- Maps a narrow range of low gray level values into a wider range of output levels
- Opposite is true of higher values of input levels
- To accomplish spreading and compressing of gray levels
- Imp: It compresses the dynamic range of images with large variations in pixel levels

  Ex: Fourier spectra

Log Transformations

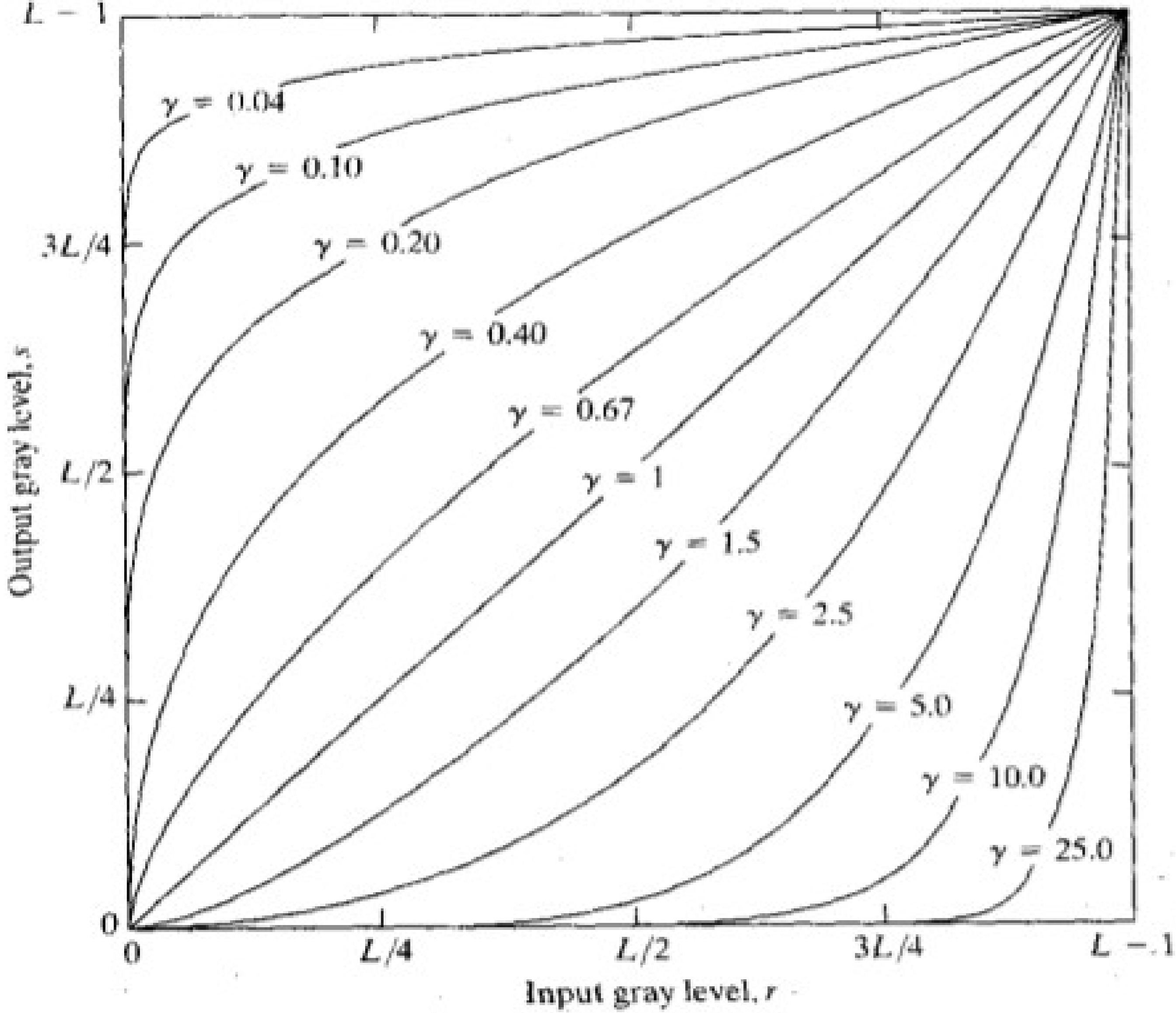





Power law Transformations

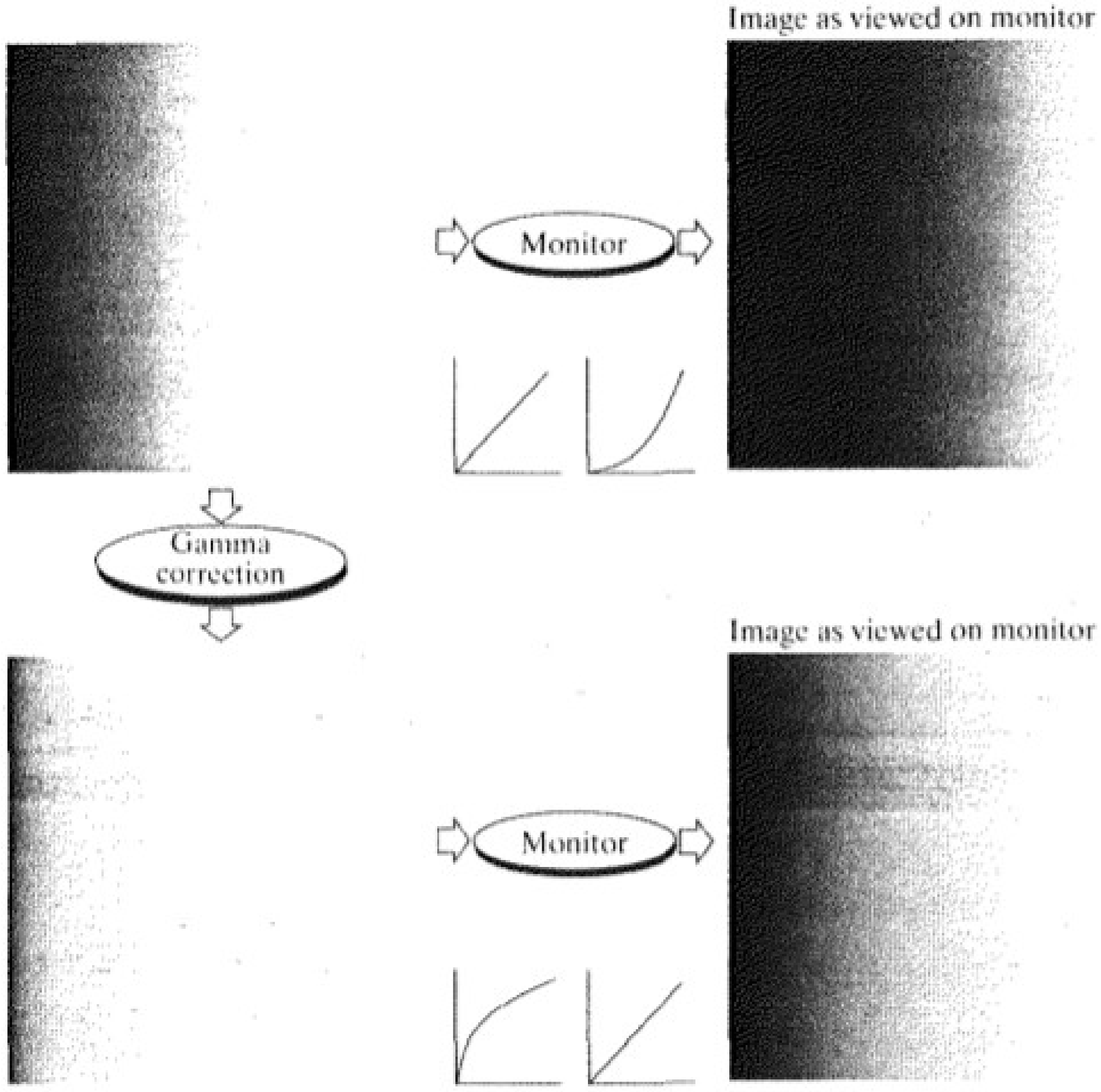
$$s = c*r^{\gamma}$$

- Maps a narrow range of low gray level values into a wider range of output levels, when 'γ' is fractional
- Opposite is true of higher values of input levels. when 'γ' is higher
- The process used to correct the power-law response phenomena is called *Gamma-Correction*
- Gamma correction is important when displaying images on computer screen

Power law Transformations



Gamma Correction



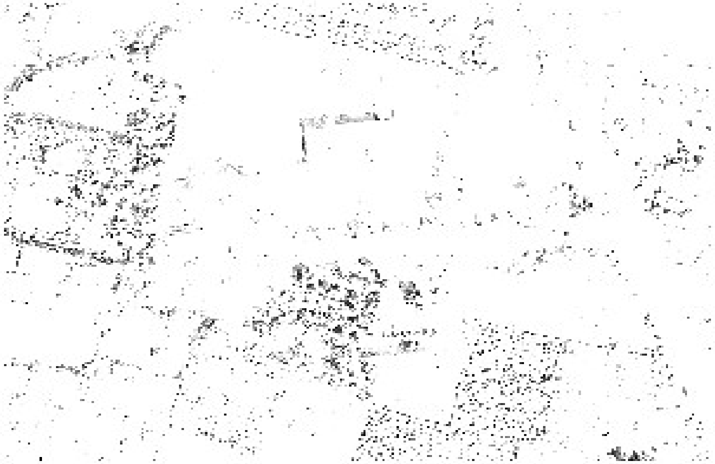
Power law Transformations

Gamma=0.1

Gamma=0.5

Gamma=1

Gamma=1.5



Piecewise Linear Transformation Functions

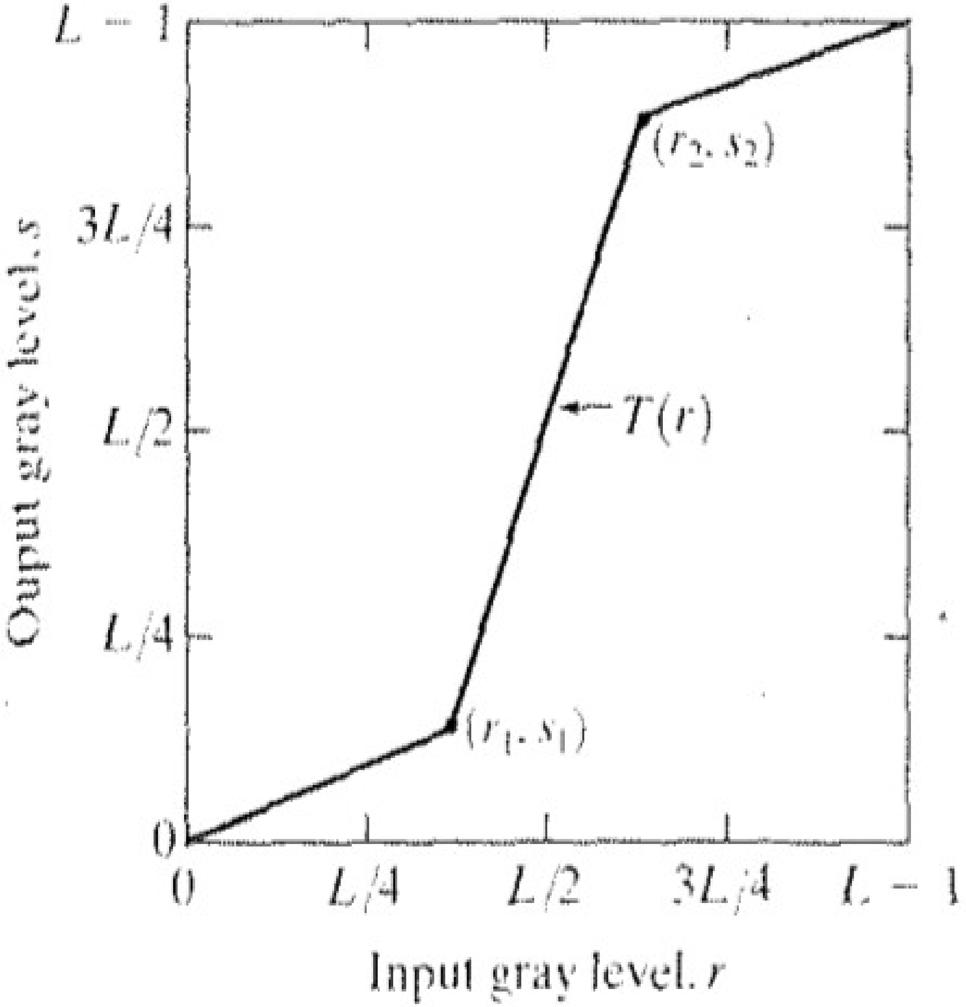
- A complementary approach to the previous methods
- These functions can be arbitrarily complex
- Some important transformations are purely piece-wise linear transforms
- Disadv: Specification requires more user input

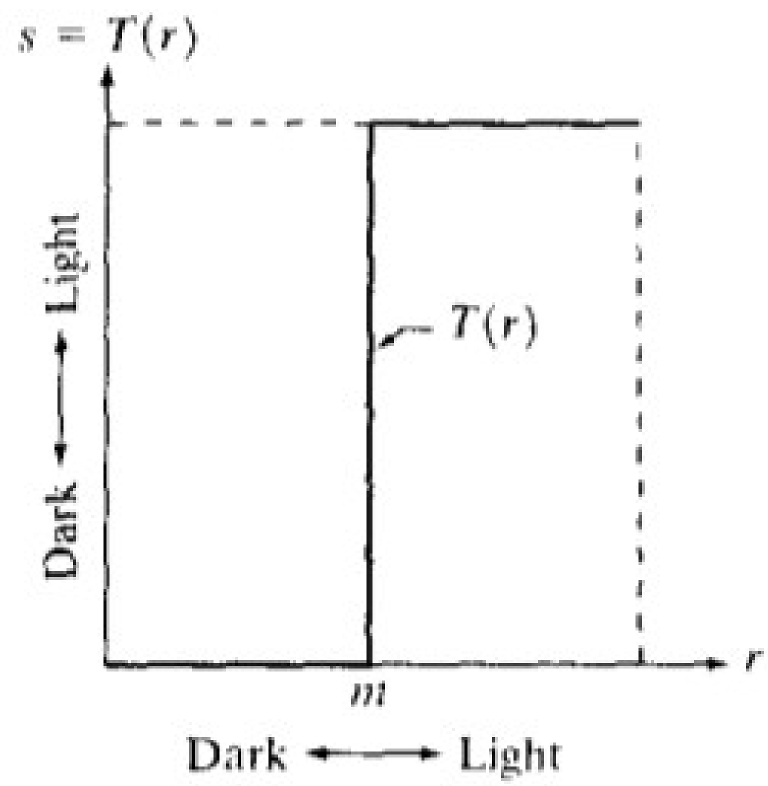
Ex: Contrast stretching transform

Contrast Stretching

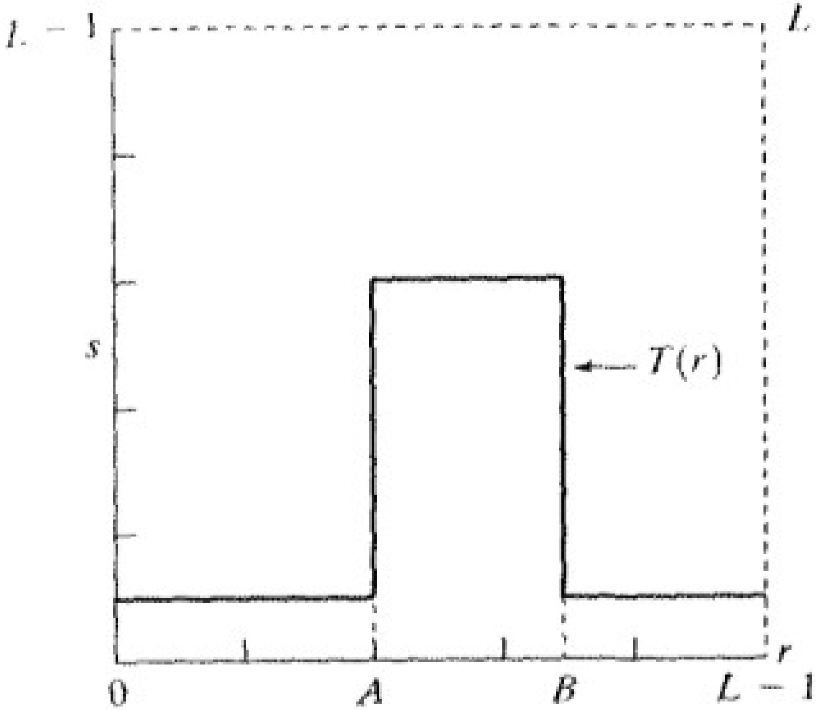
- Low-contrast images : Poor illumination, lack of dynamic range in sensor, wrong setting of lens aperture
- Contrast Stretching: To increase the dynamic range of the gray levels in the image

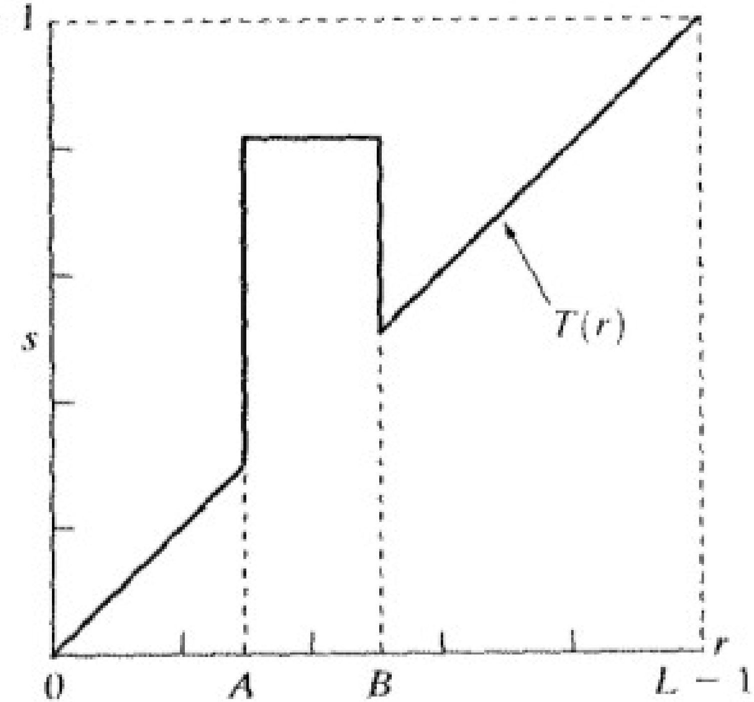
Contrast Stretching





Gray-level Slicing



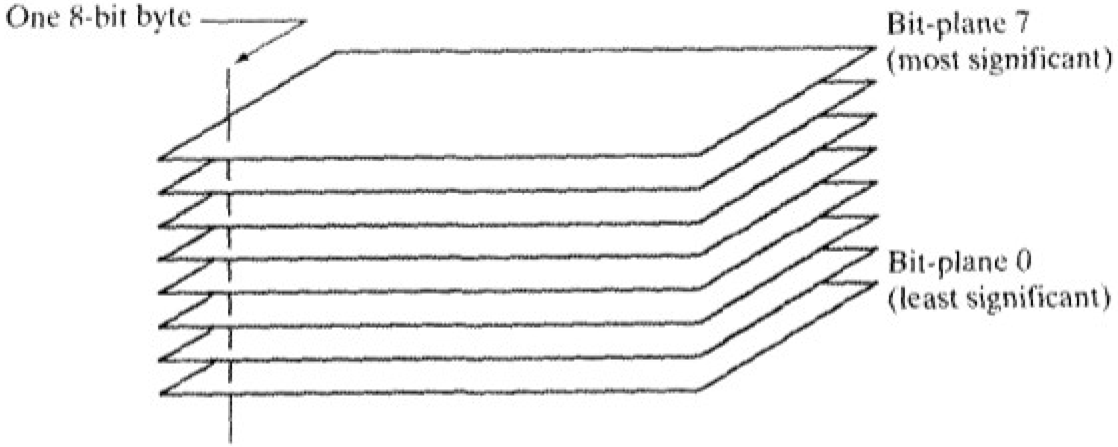


Highlighting a specific range of Gray-levels:

1. Displaying high values in the range of interest and a low value for all other values
2. Brightens the desired range of gray levels but preserves the backgrounds and tonalities

Bit Plane Slicing

- Contribution made to total image appearance by specific bits
- Higher order bits contain the visually significant data, the other bits contribute to more subtle details of the image
- Useful for analyzing the relative importance played by each bit plane
- Aids in determining the adequacy of the number of bits used to quantize each pixel
- Also in image compression



Bit Plane Slicing